LETS LEVITATE

The Superconductor Hobby Club
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ON FURNACES

Paul Smith

Current high temperature superconductors require furnaces that are capable of generating temperatures of 900°C to 1300°C and that can contain an atmosphere other than air (usually oxygen). This combination of requirements is ideally suited to the common laboratory tube furnace.

Tube furnaces are just what the name implies. They are built to house a mullite or alumina tube. They are relatively simple to build, and are composed of a cylindrical heating element held in place in a sheet metal housing by high temperature insulation. There are usually 4" - 5" of insulation between the heating element and the metal shell.

All components are cored before assembly to allow the mullite tube to pass through the furnace unhindered. The electrical feed throughs for this type of furnace generally come out through the side and are often provided with taps to allow modification of the temperature vs. length profile by shorting out unwanted heating sections.

It is difficult for an individual to obtain small quantities of the necessary materials required to build a tube furnace. If your time is valuable and you have $800 to $1200 in your pocket, it is probably preferable to buy one already constructed. There are many reputable firms making these furnaces. Two that come to mind are Marshall Furnace Co. (408-438-0222) and C M Mfg. (201-338-6500). It may still be necessary to buy the mullite tube separately.

The tube outer diameter will be the same as the furnace core hole and the length should be sufficient to extend 8" - 10" beyond the furnace at each end to keep cool. Metal end flanges and viton gaskets to provide a gas tight seal between the tube and air are also required. If the furnace is to be run horizontally, a mullite "D" tube also will be required. All of these items are available from McDanel Refractory Porcelain Co. (412-843-8300). There are some price minimums involved.

Also required are a power supply and a temperature indicator. The simplest form of power supply is a variac (variable transformer). These are available at most surplus electrical equipment dealers at highly discounted rates or through Superior Electric (914-698-9332). Be sure to get the right size, voltage and amperage, to handle your furnace. To measure the temperature, a type K thermocouple and either a digital voltmeter or a temperature indicator, is required. Control systems combining temperature measurement, indication and SCR power supply and control are also available. A good source for temperature measurement and control equipment is Omega Engineering (203-359-1660).

If this all sounds like a lot of junk to pull together, the alternative is an integrated tube furnace, with the furnace, power supply, and temperature indicator and control all integrated into a slick package. Many manufacturers offer this set up as well; notable names in the field being Lindberg (414-261-7000) and Thermolyne (319-556-2241).

ON PAPERS & REPORTS ...

Technology Futures Inc., Austin, Texas (Nancy Powers, 512-343-6468), is one of several companies involved in aiding business decisions relating to superconductivity. Their publication is titled *Superconductivity: A practical guide for decision makers.*

ASM International, Metals Park, Ohio (216-338-5511) gives an overview of the latest developments in Japan in a report titled *High Temperature Superconductivity Materials, the Current Situation.*

Criceram, a subsidiary of the Pechiney Group, Paris, France announces a successfully completed development of an industrial process to manufacture a precursor powder, especially designed for making YBC superconductors with a 70% minimum content of the superconducting phase. (Tel:203-625-8815).

SCUIPS

The Cambridge Report on Superconductivity reports that Dr. T. Ogushi of Kagoshima University, Japan, has been successful in replacing all copper atoms with **niobium** in the LSrCuO system and has been able to obtain true Room Temperature plus Superconductivity showing both zero resistance and Meissner effect. The reported compound is a mixture of La_2O_3: SrO: Nb_2O_5 in a 1:1:1 mole ratio; showing a T_c of 320°K (lukewarm 117°F) and exhibiting 30 to 70% Meissner effect. His paper is expected in the Journal of Low Temperature Physics in March.

Ebil and his colleagues at Georgia Institute of Technology have reported that they can reproducibly formulate a YBCO composition exhibiting zero resistivity and AC Josephson effect at about 500°K (227°C). Meissner effect tests have not been announced yet.

Scientists at the Argonne National Laboratories have announced the construction of a 50 rpm electrical motor using superconductivity. Superconducting YBC disks rotate an aluminum disk containing 24 small electromagnets by Levitation at 94°K. This unit will be exhibited in Science gatherings.

Kostadinov, Bulgaria, reports that the Physicists at the University of Sofia, confirmed the presence of resonating valence bonds in the YBCO system using Mossbauer Spectroscopy.......shedding additional light towards the understanding of the fundamentals of high T_c superconductors. A similar topic is discussed by E.W. Fenton of NRC, Ottawa, Canada and S.H. Liu of Oak Ridge National Laboratories, following the theory presented by P.W. Anderson in Science (1987 - pp 1196-1198).

A.I. Technology, Princeton, NJ (609-882-2332) is a source for obtaining very low resistance silver based epoxy pastes, such as can be used in making connectors to superconductive ceramics, etc. The reported resistivity of the room temperature cured material is 50 micro-ohm cm.

Superconductive Components Inc., Columbus, Ohio is interested in promoting superconductor hobby work. Those interested can contact T. Welmut of SCI.

FERROELASTIC SUPERCONDUCTORS

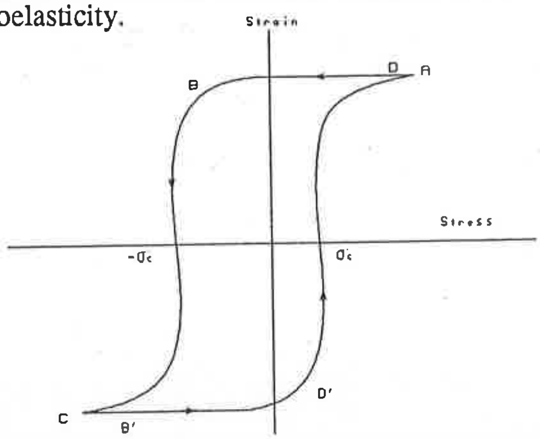
G.V Srinivasan

Recent advances in high T_c superconductors have aroused the interest of the scientific community in understanding the concept of superconductivity, which has been around for a while. Though lot of efforts are diverted into processing stable high T_c superconductors and mechanistic interpretation of super- conductivity, little is being done or known about interactive coupling of other physical properties with superconductivity. This article illustrates the interactive coupling of one such physical property, called the **Ferroelasticity** with superconductivity.

Ferroelasticity is often accompanied by the onset of additional cooperative phenomena, such as magnetic or ferroelectric ordering. At least, in two cases, the superconducting state appears to be associated with the ferroelastic transition. The strong interactive couplings possible in such multi-property phase transitions open an attractive field for study.

What is Ferroelasticity ?

Aizu [1] recognized ferroelasticity as a new property and classified some crystals with certain symmetry to be ferroelastic. A crystal is said to be *ferroelastic*, when it has two or more orientation states in the absence of mechanical stress, and can be shifted from one to another of these states by a mechanical stress. This process is illustrated further using Figure 1. which shows a hysteresis loop between stress and strain that is characteristic of ferroelasticity.



In this figure, segment AB corresponds to one orientation state and segment CD corresponds to another crystal orientation state. Segments BB' and D'D correspond to stages of transition between these states. A coercive stress, σ_c is needed to cause the transitions, or in other words, σ_c is needed to switch the orientation state. A cluster of unit cells that have a particular orientation is called a '*domain*' and the transition of one orientation state to another is called domain switching.

At this juncture, it is worth pointing out that *ferroelectrics* show a phenomenon of *dielectric hysteresis*, which is similar to the phenomenon of ferroelasticity discussed here.

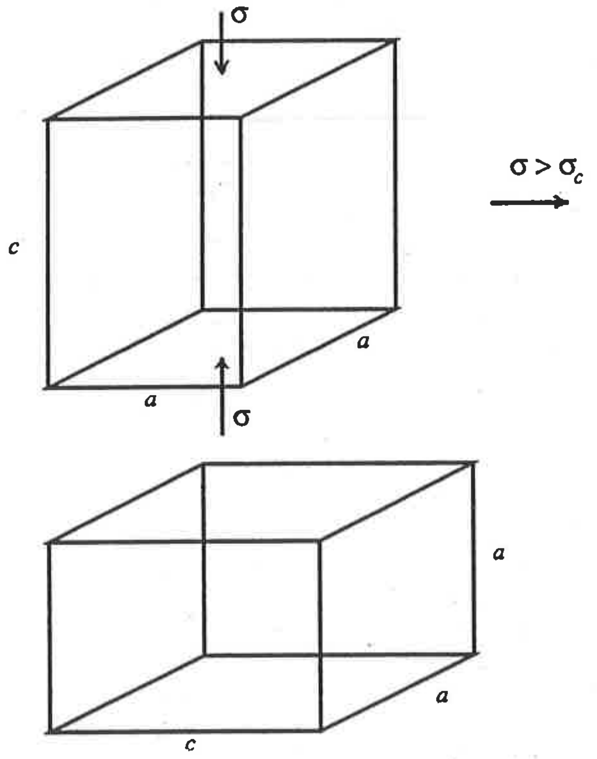


Figure 2. Change of orientation from one state (c axis parallel to stressing direction) to another (c axis perpendicular to stressing direction).

How a permanent strain is created is explained as follows: Consider a tetragonal unit cell as shown in Figure 2.

When a compressive stress in excess of the coercive stress, σ_c is applied as shown in Figure 2, the *c* axis that is initially oriented parallel to the compressive direction, will now align itself perpendicular to the compressive axis (stable position). During this process, in which the *c* axis becomes an *a* axis, the strain created is equal to *(c-a)/a*; (path BB' in the hysteresis loop). A stress in the reverse direction (tension) is required to bring the *c* axis to the initial orientation; (path D'D in the hysterisis loop).

This concept of domain reorientation is used in toughening of brittle materials, like ceramics. Virkar and Matsumato [2] have shown that zirconia, a structural ceramic material exhibit toughening due to ferroelasticity. The author also observed ferroelastic domain switching in doped zirconia single crystals [3].

Ferroelastic Superconductors

Abrahams [4] in his review article on 'Ferroelasticity' cited two cases that are ferroelastic superconductors. V_3Si has a $T_c = 17^oK$. At this temperature, these crystals have tetragonal symmetry. Superconducting V_3Si has been demonstrated to be ferroelastic by reorientation of the *c*-axis on application of uniaxial compression along plane {100} [5].

In another study, it is reported that uniaxial compression along {100} or {111} planes on a single crystal V_3Si caused T_c to shift as much as 0.4^oK [6]. Nb_3Sn is also found to ferroelastic and superconducting with $T_c = 18.1^oK$ [7]. The effect of stress states on T_c has not been reported.

Discussions

For a crystal to be ferroelastic, there has to be at least two orientation states available. Therefore a crystal with cubic structure cannot be ferroelastic, and has to be at least tetragonal or even lower symmetric group to exhibit ferroelasticity. V_3Si undergoes a cubic to tetragonal crystal structure at about 21^oK [8]. The *c/a* ratio increases with lowering of temperature and reaches a maximum just about 17^oK, which is the critical temperature for superconductivity for that material. Also in Nb_3Sn, the cubic to tetragonal transition is around 43^oK [7]. The *c/a* ratio rapidly decreases, with decreasing temperature, reaching a constant value of 0.9938 by $T_c = 18.1^oK$.

So in both these cases, the onset of superconductivity is when the lattice is most distorted from its original prototype phase. The above observation does prompt one to speculate the effect of ferroelasticity on the onset of superconductivity. In V_3Si, the T_c is reported to depend on the stress state. The change in T_c is about 2.3% which for higher T_c materials will correspond to a modest change in temperatures. Also the effect of change in stress state on the critical current density is not reported and need to be understood.

Is the superconducting Yttrium Barium Cuprate ferroelastic? If so how does the ferroelasticity affect the superconducting behavior and vice-versa? To answer this question, one must firmly understand the crystal symmetry of the superconducting phase. Only a classified set of symmetry transformations lead to ferroelasticity. The 123 compound starts with perovskite structure and finally ends up in orthorhombic structure (after annealing); i.e. from a higher symmetric to a lesser symmetric structure. This kind of transition is characteristic of many existing ferroelastic materials. So the 123 compound has a good potential to be a ferroelastic superconductor. Unfortunately, the symmetry groups are not well established yet.

If the 123 compound is ferroelastic, then this might lead to finding some other basic clues in the design of newer superconductors from multi-property materials. When this phenomenon is understood in the high T_c ceramics, the improved fabrication by using the toughening techniques developed in other ferroelastic systems would become possible.

It is interesting to note that some studies are already ongoing in understanding ferroelectric or dielectric hysteresis in the Rare Earth-Barium-Copper-Oxide systems in China by Yang, et al. [9].

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The State of Scientific Research In Third World Countries: Some Observations

Rukmani Jayaraman

Perhaps the relative neglect of indigenous research as a factor arises from the view of scientific knowledge as a peculiarly western creation. Yet the survival and development of pre-colonial Asia, Africa and Latin America were founded to a greater or lesser extent upon indigenous scientific and technological traditions, many of which exercised a profound influence on European civilization.

Since the middle of the 18th century, the countries of the west (the colonial powers) have overtaken the post-colonial or colonial societies in the development of scientific knowledge, and have left them lagging far behind. My intention here is not to state reasons as to why or what brought about such dramatic changes in both types of systems. Instead, this is a discussion of the nature of scientific research that is being carried on in the third world and the limitations of their R&D.

Post colonial societies vary significantly in their research capacities. At one extreme are the newly industrializing countries eg.,Brazil, Korea, Taiwan, India; at the other, the research deficient countries of Africa. Overall, third world R&D expenditures as a proportion of global R&D expenditures, have been estimated to be as low as 2%. Scientists engaged in R&D and living in the third world number half a million compared with four million in developed countries.

Apart from basic lack of resources, there are other problems that third world scientists face. One is the level of their training. The second is the relevance of that training - usually obtained in a developed country environment - and its orientation to the local situation. Thirdly, there is a paucity of opportunity for intellectual interchange with their peers. Many a third world researcher is an intellectual recluse.

Intellectual solitude among third world scientists hinders the *creation of an environment* in which researchers are able to produce and communicate research results; in which the populace, government and the private enterprise have the will and capability to make optimum use of those results. The self confidence, stimulation and effectiveness of a scientist depend on contact and exchange with his/her peers. Researchers can only be effective if they have access to the writings of their colleagues and outlets for their own work. Unfortunately, the role of libraries, documentation centers and so on is even less appreciated in many developing countries, than that of researchers.

For this reason, third world governments have probably spent, on the aggregate, many millions of dollars for feasibility and other studies when the information produced could have been obtained for much less from local archives or international data banks.

Another necessary part of a conducive environment is all the institutional apparatus that looks after the "D" in R&D. The best research results are only of academic interest until transformed into policies, products and systems - or "D". Development in this narrower but important sense is as lacking as research in the third world.

Researchers face a stumbling block created by journal and publishing houses in the west. Some of the excellent material produced by research in the third world is of course, sometimes, published in international journals. But in other instances, the output of a project may never appear in such publications, either because the research is considered by the editors to be substandard or because the subject matter has little international relevance. Consequently, a paper or booklet recording the results of such research may be the only existing research document dealing with that topic for a particular country. Such material, in addition to its limited distribution, might be published in languages spoken in specific localities.

Publication and dissemination are frequently essential to the application of knowledge and unfortunately the work of scientists in a number of third world countries, or countries with different political ideology, despite its worth and importance, goes unnoticed.

Despite these difficulties there is hope. Several governments of developing countries in Africa and Asia have set targets for R&D. Investment levels indicate at least an awareness of the value of scientific solutions to their continent's pressing problems. Many have been prevented by recession from achieving their goals. Nevertheless, allocations for R&D have been increasing in many cases; Such allocations are being included in national budgets for the first time in many others. More and more national research institutes and even ministries of science and technology have been added to national administrative structures.

India: an example

In terms of size and scientific work force, India is placed third after USA and USSR. With its enormous research infrastructure, India is able to pay increasing attention to industrial research. It's most dramatic achievement has been in the field of nuclear physics . Also there are tremendous advancements in areas of space and satellite technology, superconductivity etc., to name a few. In these areas India is considered on par with some of the western countries. In India, two national committees on superconductivity have been set up with their Prime Minister as the chairman of one of them. This indeed shows the commitment of their government to promote further research. However, setting up committees is only the first step.

The real task is to see that the results of the valuable research done in this area is translated into practical technology which promotes development. So far one of the basic problems which has slowed down the pace of progress in this field is in the area of practical applications.

Research is a necessary condition for the development of third world countries: development cannot take place without the appropriate research. However, research is not a sufficient condition for that development. Other factors are necessary if development is to take place. Among them are a carefully conceived overall science and technology strategy, a conducive research environment, favorable domestic, social, political and economic factors, a conducive international environment and of course, time.

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WHY NOT OTHER COMPOUNDS & YET ANOTHER THEORY (Part II)

Neale R. Neelameggham

Amateur scientists, like the author, believe that there is a correlating '*d*' electron oscillation theory that is common between high T_c compounds discussed thus far and in the Ogushi's $La_2SrNb_2O_{10}$ compound's superconductivity. A stoichiometric analysis of Ogushi's compound also indicates an excess of oxygen from the starting materials as in the LaSrCuO or the YBaCuO superconductors.

This theory is based on a simplistic approach, the rare earth elements with a lone electron in their '*d*' orbital provide the room for the outer most electron of elements such as copper or niobium to oscillate back and forth to their '*d*' orbital which is partially out of order in their position in the periodic table.

This oscillation may cause a resonance at particular temperatures resulting in freer passage of current through the matrix showing zero resistivity and superconductivity. Now one may ask, what is the role played by oxygen or excess oxygen in these compounds?

One thought that comes to mind is that the compound has to achieve electro-neutrality through an anion in the system, either by an electronic bond or a covalent bond, to facilitate current transfer without true electronic movement across the material. The alkaline earth oxides such as strontium and barium oxides not only tend to help stabilize the compound, but also provide oxygen enrichment by their partial conversion into stable peroxides.

Now having this another theory, explained in simple terms, inventions of newer compounds based on Chromium, Palladium, Cerium, Iridium and possibly Protoactinium substitutions for copper or niobium should not come as a surprise to higher T_c enthusiasts.

Other transition elements following chromium, niobium or actinium in their respective periods also have a possibility of exhibiting the '*d*' electron oscillations to a lesser extent, leading to very low electrical resistance at particular temperatures.

One should note that Rhenium trioxide exhibits a room temperature conductivity of about 85% that of copper, and that rhenium is known to have an outer shell electronic configuration of $5d^5 6s^2$ or $5d^6 6s^1$ depending on the compound.

On Submitting Articles

Articles on superconductivity and related interests are welcome. Please submit articles either in double space typed format or as an ASCII text file in 5.25inch floppy disk for IBM PC compatibles. Or the articles can be uploaded to Mount Olympus BBS Superconductor section (Tel:801-942-0620); and call 801-596-3592.

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Superconducting Magnets in Magnetic Resonance Imaging

K.Ganesan

Nuclear Magnetic Resonance Spectroscopy (NMR) was discovered in 1946 independently by the Research groups headed by Purcell and by Bloch. Medical applications of NMR was influenced by the studies of Lauterber and Mansfield in 1973. Nuclear Magnetic Resonance Imaging (NMRI), originally called ZEUGMATOGRAPHY and was also referred to as Magnetic Resonance Imaging (MRI).

There is some reluctance in using the word 'Nuclear' since the method is safe to the patient. MRI generated excitement in the field of medicine: it is now possible to perform non-invasive hazardless examination of the interior organs and structures of living human patientss. The potential of MRI as a diagnostic tool is the reason why it is popular in many hospitals today.

When a sample containing NMR active nuclei is placed in a uniform applied magnetic field, the nuclei will precess (orbiting like a toy top) around the magnetic field. The frequency with which the nuclei precess is called Larmor Precession Frequency. The frequency also depends on the nuclei of interest (eg. proton, fluorine, phosphorus, etc.). The sample is also surrounded by a radio frequency coil.

NMR Imagers apply a relatively strong linear magnetic field gradient in addition to the pulsed radio frequency (RF) to excite the nuclei in the sample in a controlled manner. The Larmor Frequency, w, depends on the location of the nuclei relative to the gradient. Conversion of frequency to the distance calculations are usually made using computers. The resolution of the image thus obtained, depends on the homogeneity of the applied magnetic field and also the gradient. The NMR signal which comes from the NMR active nuclei depends on the applied magnetic field strength. If the magnetic field strength is greater, the NMR signal is also larger. So there is an advantage of taking MRI images at higher magnetic field strengths.

There are some cases in which the nuclei does not experience the applied magnetic field because of the electronic screening of the nucleus (called Chemical Shift). The Chemical Shift also depends on the magnetic field strength, using this principle it is possible to separately identify the fat and water using MRI.

There are variety of techniques to take two dimensional or three dimensional MRI pictures of the object of interest. If it is desired to take 2-D or 3-D MRI pictures, it would be better if the field is uniform throughout the region of interest. The bore diameter of the magnet has to be big to accommodate the patient.

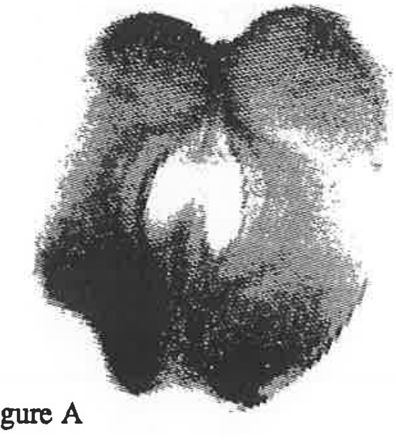
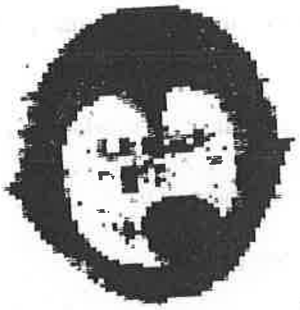


Figure A

If the external magnetic field is uniform throughout the region of interest, the resolution can be smaller for constant gradient magnetic field strength. The Chemical Shift imaging will be distorted if the magnetic field is not uniform. The large bore diameter and also horizontal bore is convenient for MRI Imager. The good magnetic field stability, high magnetic field strength and numerous other advantages favor the use of Superconducting Magnets for MRI. The uniform magnetic field for larger volumes in superconducting magnets is achieved by having superconducting shim coils and room temperature shim coils. Hence most of the commercial MRI use superconducting magnets.



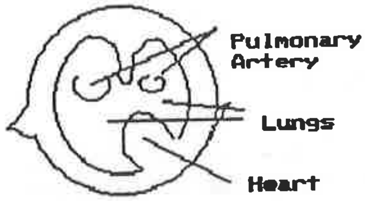


Figure B

The MRI picture (A) shown here is an axial slice proton (water) density image taken using Oxford Superconducting Magnet (which is a Nb-Ti alloy in a protective matrix of copper) of an apple slice. The dark color indicates more protons. The next picture (B) is an axial slice of a rat. The heart and lungs are indicated in the picture. The resolution of the picture is approximately 2mm x 1mm x 1mm along three directions.

Superconducting Generator Development

Krishnan Moten

The development of superconducting AC generators started in the mid 60's. The first armature machine with the use of rotating superconducting field winding and continuous transfer of liquid helium was tested at MIT in 1971.

Early in the analysis of AC superconducting machines, considerable effort was devoted to searching for the optimum machine configuration, specifically the rotor and stator. The next was finding suitable superconducting coils that would serve as the field winding. Further in the development process was design and construction of several small machines to prove the significant increase in power density. However, these early experiments were based on two-dimensional models of the machine fields and did not adequately account for the severe conditions imposed by faults close to the machine terminals. Transient effects were not fully analyzed.

Recent development in constructing superconducting machines is based on a three dimensional magnetic field analysis. A number of models have been developed with varying complexity and accuracy for the prediction of different aspects of machine behavior.

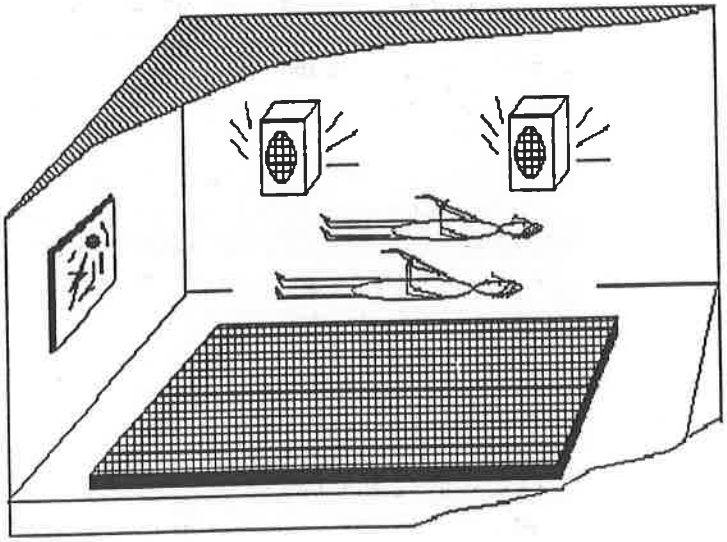
Considerable analysis has been done to asses the system stability gains from various proposed generators subject to different fault sequences and disturbances. Though, the obtained results appear to be realistic, no superconducting machines have yet been operated on a system during any transients. Transient effects are necessary to know the disturbances imposed on the superconductor during machine fault.

Despite the current limitations, the prospects for practical superconducting generators remain very bright, especially in light of the recent discoveries of high temperature superconductors. Superconductors at these temperatures could well alleviate some of these difficult problems of superconducting winding stability during machine transients. The critical next step is to establish the design and experience base to insure that the machines will operate reliably through all transient situations.

Out of Body Experiences

William L. Jackson

Recent developments in large scale superconductors have led to the newest YUPPY trend. Out of Body Experiences Inc. (OBE) has planned to open the first public human Levitation Chamber. Customers wear a light weight magnetic suit and suspend themselves in "thin air" over a 20' x 20' superconductor. Complete sensory deprivation is attained by careful impedenceless ambience, ambient temperature and lack of light. Other "Experiences" are planned, including group sessions, laser light shows, and rockin' with Pink Floyd.



SCUIPS

Many of you may be aware of the advances in other high T_c compounds being announced in the past 100 days. Maeda and Togano of National Research Institute for Metals' Tsukaba Laboratories, Japan as well as Paul Chu of the University of Houston announced T_c's of 90°K to 110°K in BiCaSrCuO (bismuth - calcium - strontium - copper-oxide) compounds with or without some Aluminum to spike it up. These announcements were made in January 1988.

Although prior references to the Bismuth substitution for rare earth by Raveau or Dr. Wu are quoted in these developments, it is surprising to see the lack of reference to the work done by Kilcoyne and Cywinski from U.K. mentioned in December '87 issue of Let's Levitate on the benefits of using bismuth as a partial substituent in the YBaCuO 123 compounds.

The proportions used in the bismuth compounds are different than 123 compounds: Bi_2O_3: $3(Sr_{(1-x)}Ca_xO)$: 2CuO is the starting proportion with x being in the 0.13 to 0.30 range.

Hermann and Sheng of University of Arkansas have announced the highest T_c of 120° to 125°K compound of Thallium, Calcium, Barium, Copper oxides in February. Their paper appeared in Nature (March 3 and March 10 1988 issues). This rare earth free compound is made using Tl_2O_3: $Ca_{1.5}Ba_{0.5}O_2$: 3CuO starting mixture. It is interesting that one of the highest T_c compounds known in 1932 was a thallium carbide with a T_c of 9.2°K !

Many Thallium compounds have a perovskite structure, especially Tl-RE-carbides. Penicillamine HCl is an antidote for thallium poisoning. Western world production capacity of such materals is only about 1500 tons per year; manufacturing of Thallium due to its poisonous nature had been halted in the US in the mid-seventies. The electronic and copper plating industry import thallium from South America. Room temperature superconductors of the future may also be thallium compounds.

Several groups have been making strides in making the YBaCuO compounds ductile, using silver as an additive; University of California, SanDiego, Ohio State University, Columbus, MIT teams, and several European research groups are among those working in this line. Goodenough, University of Texas, Austin subscribes to the formation of peroxide ion formation in his work reported in Materials Research Bulletin, March 1988 in the YBaCuO superconductors.

Microwave oven processing of ceramics and superconductors are reasonably well known. An excellent compilation of temperatures to which several metals, oxides and minerals are heated in a microwave oven can be found in the article by S.L. McGill and J.W. Walkelewicz of USBM, Reno published in J. Microwave Power E^2 1987, p175-177. A two hour recipe with about 45 minutes microwave oven processing of YBaCuO superconductor is published by Baghurst, et al (Nature, Vol 332, March 24, 1988, p311).

The hobby kit for YBC superconductors supplied by Colorado FutureScience, Inc. is unique in the fact that no pelletizing or press is required in making the demonstration ceramic discs. Further, the basic kit provides about 76gm of reagent capable of making several discs of smaller size available with other kits. Interested parties contact Jerry L. Emanuelson 719-634-0185.

Thermocouple material for cryogenic temperature measurements is chromel-P vs gold with 0.07% atomic iron; sensitive in the range 0^o to 280^oK.

Superconductivity for Laymen

K.Jayaraman

The age of superconductivity is here and it is time to think about what this is going to do to us and to our lifestyles. Let us therefore examine it in very simple terms. To begin with let us discuss the term 'superconductivity' itself. What is superconductivity, why is it important and what is its potential?

The electrical conductors which are being used today resist the flow of electric current through them, thus wasting energy in the form of heat. With superconductors, as the name implies, there is no resistance to the flow of current, thus no waste of energy. In the last 75 years this phenomenon occurred only at a temperature near absolute zero (0^oK or -460^oF to 20^oK or -424^oF). Therefore, for superconductivity to occur, the conductor had to be cooled to these very low temperatures. This was not very practical and also the process was very expensive.

In recent years giant strides have been made in R & D and new compounds were found which exhibited superconductivity at much higher temperatures. As of now a stable compound of Y-Ba-Cu-O (Yttrium - Barium - Copper - Oxide) exhibits superconductivity in the temperature range of 80^oK to 100^oK. There are other compounds which exhibit superconductivity even at higher temperatures but are either unstable or just being verified by the Scientific community. As nitrogen is a liquid above a temperature of 77^oK and it is inexpensive to achieve this temperature, already a wide range of applications are feasible.

Why is Superconductivity important?

When superconductivity starts occuring at room temperature, it becomes very convenient for practical applications. It will reduce the cost of energy, reduce transportation costs, provide better medical diagnostics and provide less expensive and faster computer devices, etc. So in effect, this is going to touch our everyday life and make it more comfortable, affordable etc.

What is its potential? Immense! Let us first mention the major categories where they can be used and elaborate a little bit on them. Magnets: As the superconductor has a higher magnetic field for smaller size, therefore, lower cost-very high field magnets would become available with higher temperature superconductors. They can be used in medical diagnostics and research, magnetic resonance imaging and spectroscopy. These magnets can be used in metallurgical applications for ore refining. The magnets can also be used in the transportation area for the magnetic levitation of trains. These trains levitate over the rails and can travel at very high speeds. In the area of particle accelerators, these magnets play a major role - for nuclear fission and fusion - and for use in other research areas.

Power generation: In this area the potential for superconductors is vast. They can be used for power generation, transmission and storage. The major problem in this area is how to form the brittle components into wires, how to keep them stable and how to orient the crystalline structure to maximize its current carrying capabilities. How to prevent the loss of superconductivity, which occurs when any one of the three limits are exceeded, strength of the magnetic field surrounding it or the current density or the superconducting transition temperature is exceeded.

Electronics: To make devices which are faster than today's devices, we can package more components in a given area (high density).

One can see that the potential is vast and it will change our lifestyle in the near future.

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Ceramic Superconducting Magnets: Design And Construction Considerations

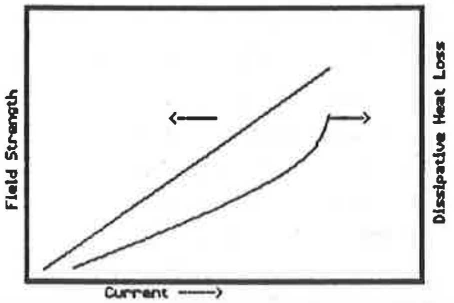
Ashok C. Khandkar, CERAMATEC, INC.

New superconducting ceramic materials are expected to find one of the earliest technological applications as magnets especially for high field applications. An example of some of the possible early applications are for use in ultra-sensitive magnetometers used for detection of small magnetic fields. The greatest impact of the new materials will, however, be in the area of electromagnets required to produce very strong fields. The potential applications range from biomedical instrumentation such as computer aided tomography (CAT scanners) in the field of medicine, to particle accelerators (superconducting super-colliders) in the field of high energy particle physics.

In the design of high field magnets, while the basic principles remain the same, the considerations involved in engineering a system using high field magnets are quite different from conventional magnets. This article explores some of these considerations; the salient differences between conventional magnets and superconducting magnets are discussed. The term magnet is used as a synonym with the term electromagnet.

Conventional Magnets

To begin to appreciate the advantages offered by high field magnets made from superconducting materials the features and limitations of conventional magnets must be pointed out. Conventional magnets are generally made from copper coils wound around a soft iron core. When an electric current is passed through the coil a magnetic field is generated in proportion to the magnitude of the current being passed. The higher the current passed the stronger is the force of the magnetic field.



Schematic of Conventional Magnet Characteristics

As one might guess, there are limitations to the maximum strength of the magnetic field that can be produced by such electromagnets. The main limitation stems from an important fact that the conducting coils heat up rapidly with the passage of current. This heating effect, known as Joule heating is proportional to the square of the current being passed.

Figure 1 shows the variation of field strength and heat dissipated as a function of the current. As the coil winding attains higher temperatures, the resistance of the conductor increases thus effectively restricting the total current that can be passed through it, for a given impressed voltage.

In order to get higher currents through the coil it then becomes necessary to cool the coils. This is done by cooling water coils around the magnet coils for ordinary applications or by refrigerative cooling for special applications. Despite these "tricks" the maximum magnetic field strength of conventional magnets is around two Tesla. This is because the soft iron core saturates and can no longer support higher fields. With special alloying elements added to iron, the maximum field strength that can be attained is about three Tesla.

Tesla

A Tesla is unit of magnetic field strength. Its direction is given by the tangent to the "lines of force" which exist around a magnet. One Tesla equals 10,000 gauss; for comparison the magnetic field strength of the earth is about 1/2 gauss, typical magnets that can be bought in a hardware store have strengths of about 100 - 300 gauss.

Superconducting Magnets

A characteristic property of superconductor material -- losing all resistance to the passage of current (below the critical temperature) -- offers a great advantage to high field magnet design. The implications of this superconducting phenomenon is: if the magnet is kept cooler than the critical temperature then there would be no increase in the temperature due to Joule heating. The main consideration is that once the magnet is cooled, the ambient heat has to be kept out rather than the "generated" heat being generated away for conventional magnets.

Existing superconductor magnets made from Nb-Ti alloy are constructed by winding wires of Nb-Ti alloy into a coil around a liquid helium pipe maintained at $10^{O}K$. The assembly is surrounded by stainless steel collars which are cooled by another liquid helium pipe. The function of these collars is to rigidize the coil and contributes to stability when the coils are energized. The magnet yoke, the equivalent of the soft iron core in a conventional magnet, is generally made of an iron alloy. The magnetic field is first generated in the superconducting coils and is then induced in the yoke. The yoke is surrounded by cooling coils through which liquid nitrogen is passed. This acts as the coolant for the outside heat shield which deflects the ambient heat and insulates the liquid helium cooled core. This entire assembly is placed inside a vacuum chamber which further insulates the magnet. The design is shown in Figure 2.

The design for magnets made from high T_c ceramic superconductor materials is expected to be simpler due to the need to cool to liquid nitrogen only. The challenge lies in the fabrication of filaments or wires from the ceramic materials to make the coils. This then remains as a fabrication process development limitation. Once this challenge is overcome and inherent material instability are overcome, magnets should be easily designed and successfully engineered.

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Acknowledgement: The author would like to thank Dr. Neill Weber for critique and valuable discussions.

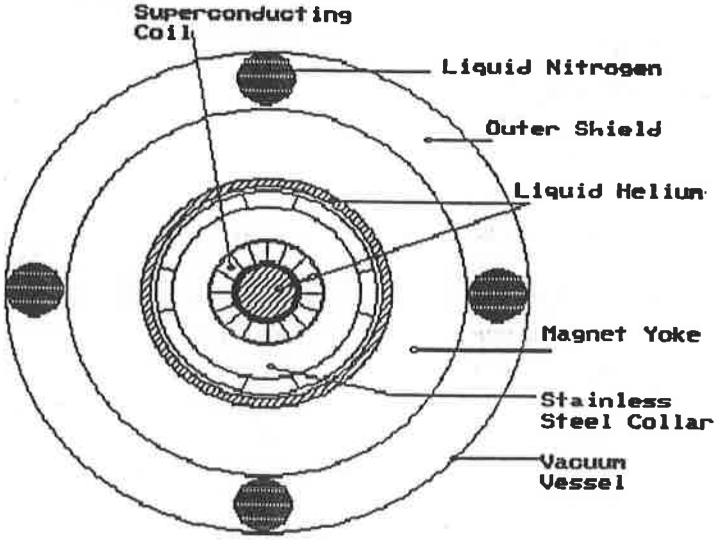

Figure 2 Schematic of a Superconducting High Field Magnet

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LOW DIMENSIONAL CONDUCTORS AND SUPERCONDUCTIVITY

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The problem of one and two dimensional metal has long been known to physicists but it did not seem to relate to any real system. With the synthesis of TCNQ salts and others which are pseudo one-dimensional (those which exhibit significantly greater electrical, magnetic, optical and/or mechanical properties along one direction), considerable attention was paid to this area[1]. To exhibit one dimensional conduction the materials should have certain features.

First, the material should have partially filled conduction band. This could be achieved by (i) non-stoichiometry of the ions along the chain in a uniform way such that the band to conserve charge is not completely occupied (ii) the formation of a semimetal from chains of adjacent redox active donors and acceptors such that a fraction of electrons are transferred from the highest occupied band in the donor to a low lying unoccupied band in the acceptor and (iii) a chain comprised of radical ions and non redox active diamagnetic counter ions. Secondly, to achieve high conductivity, it is necessary to have uniform overlap of molecular orbitals between adjacent molecules in the chain[2]. Efforts to design and synthesize a highly conductive chain has proceeded vigorously in the last decade. The following table shows some of physical properties of prototype 1-D materials.

Little[3] suggested as early as 1964 that one-D conductors may favor excitonic superconductivity. Little's model for a high temperature organic superconductor involved conduction along a linear chain surrounded by polarizable dye molecules.

Little's suggestion follows a new mechanism of superconductivity, the exciton-mechanism (Fig 1).

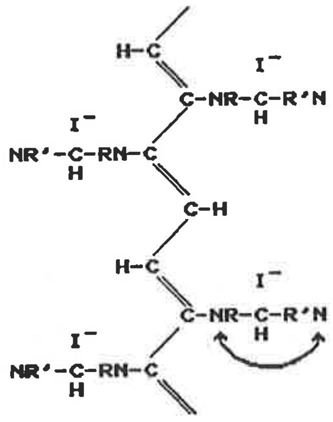

Fig1: Hypothetical Superconducting Molecule built arounf a "spine" of carbon atoms with alternating single & double bonds.

The term exciton refers broadly to any electronic excitation. The effective attraction between the electrons at the Fermi surface is induced by the exchange of excitons instead of phonons as is believed to be the case in metallic superconductors. Little suggested following the BCS theory in which the transition temperature was given by

$$KT_c = h\omega_D \exp(-1/\lambda-\mu^*)$$

where λ is the characteristic strength of the attractive interaction necessary to form Cooper pairs and μ^* measures the repulsive coulomb interaction for the phonon mechanism. The same formula was applied for the exciton mechanism. Consider now a polymeric chain (spine) and attached to this chain is a series of polarizable side chain substituents, B. As an electron moves along the spine, it will induce movement of charge in the side chains. The induced positive charge will reach its maximum value not at a time, the electron is adjacent to the side chain but a short time later (Fig 2).

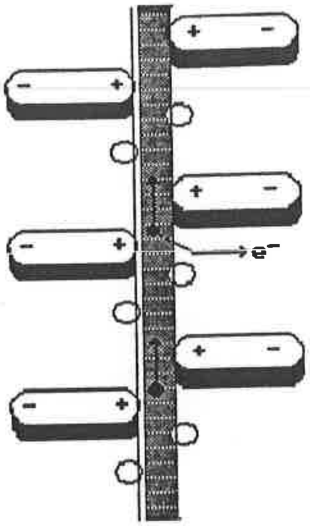

Fig 2: Electron Pairs conducting along the spine of a hypothetical superconducting molecule.

The reason for this delay lies in the finite frequency of oscillation of the charge in the side chain. A second electron is attracted by the induced charge in the side chain and just as in the case for the phonon case, one might expect to form a pairing of the two electrons. The pairing is mediated by the virtual excitations of the side chains which may be described in terms of exiton co-ordinates. While the attractive interactions would be very similar to the phonon case, the pre-exponential factor $h\ \omega_d$ could be substantially higher by a factor of $(M_{ion}/M_e)^{1/2}$ which is typically about 300. Thus it is possible to obtain very high superconducting transition temperatures.

It was also suggested that one-D structures offer the best prospects for the realization of the exciton mechanism. The rationale behind this suggestion is beyond the scope of this article. Until a few years ago, prospects of obtaining conductivities in the range of metals seemed remote.

Twenty five years since Little's suggestion higher superconducting transition temperatures have been found in systems exhibiting two-D conduction. The possibilities of designing high T_c one and two dimensional superconductors appear more likely than ever. Many of the currently proposed theories of high temperature superconductivity incorporate similar e-e or e-magneton interactions as that used in Little's hypothesis.

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SCUIPS

Arthur Fischer has published a nice description of the high T_c superconducting motor built by Argonne National Laboratories, in the April 1988 issue of *Popular Science.* A team of Hungarian scientists reported a novel design of high T_c superconducting motor.

Cava, Batlogg and colleagues of AT&T Bell Labs reported (*Nature* April 28) a T_c of 30° K in a Barium - Potassium - Bismuth Oxide compound. This is the first copper less compound with this high a T_c since Bednorz and Mueller's discovery of high T_c oxide compounds. The starting materials included Barium Oxide, Potassium Superoxide and Bismuth Oxide which was calcined at 675° C followed by a low temperature annealing in oxygen and pelletizing.

Several articles have been published on the thallium - calcium - strontium - copper oxide systems as well as the bismuth - calcium - strontium - copper oxide systems (each with or without barium). Many of the articles discuss fabrication and structure related studies.

In the fabrication side, a chemical vapor deposition technique was announced by Tohuku University and Riken Corporation in making yttrium - barium - copper oxide coated chrome - nickel pre-wound coils. This is a step in the right direction in constructing high T_c motors and generators. Leybold Inficon, Syracuse NY, (315-437-0377) announces that their Sentinel III is a reliable instrument for simultaneous rate control of superconductive thin film deposition.It is not known what substrates would be suitable with their equipment.

Perkin-Elmer announced multiple services for Superconductor Research (203-834-6491).

M. Thakur (AT&T) claims that for a polymer to be conducting, conjugation (alternating single and double bonded carbon chains) is not necessary. Polyisoprene rubber without the conjugated bonds can be made more conductive by simple iodine doping. Paul Calvert of the University of Sussex writes that there are two worrying aspects of this finding; *'First, it makes us all stupid. there have been studies of various composites of polyacetylene and rubber, but apparently no-one noticed doping and conductivity in the rubber compound ....'.* (Thakur's work can be found in *Macromolecules* 21, 661-664, 1988; Calvert's work in *Nature* 26 May, 1988, pp298).

Ultrafine Communition & Superconductivity: Are They Related?

K.Rajamani

Department of Metallurgy, University of Utah.

The answer is a resounding "yes". It is well known that powders of barium, copper ad yttrium oxide are sintered to produce the superconducting substance. For many years material scientists have been producing other ceramic components from fine powders of silicon carbide or sicilian nitride. The strength of the sintered components very much depends on the uniformity of internal structure, or in otherwords the absence of voids or pores in the specimen gives rise to higher strength. By strength we mean tensile strength - the ability to pull on both ends. But for making superconducting wires some bending strength must be imparted to BCY-oxides. So methods of encasing the oxide core in other mediums are a possibility.

Let us take the question of making an oxide sample of very high tensile strength. First, a fine powder mix is mixed with a binder, pressed to a desired shape and sintered at about 1400° C. During sintering the final crystalline structure develops. However, if there are voids in the pressed shape this void has a tendency to enlarge during sintering. To avoid this problem the particles must assume a very closed packed structure before fusing (at the grain boundaries).

When spheres are stacked together in a geometric arrangement there is void space in between spheres. However, the void volume decreases as the sphere diameter is reduced. Based on this argument, ceramics grind the powder to very fine size - micron sizes. In the case of the high T_c superconductors, the temperature of sintering is less than 1000° C, even then, obtaining close to homogeneous and dense sintered body is essential in achieving the desirable properties.

Grinding powders to micron sizes is not an easy task. To appreciate one micron size think of human hair which is about 45 microns thick. Jet mills, vibratory mills and attrition mills are used for grinding fine powders. Jet mills create intense turbulent air core in which powder gets sheared. Vibratory mills simply oscillate back and forth and so a load of steel balls sitting on the powder does the grinding. Attrition mills stir up a vessel full of tiny steel ball bearings continuously. The impact of balls causes grinding.

Finally, grinding to micron sizes requires about 2000 kilowatt hours per ton of powder. This fact can alone can make superconducting wires very expensive. But on the other hand with superconducting wires cost of electricity will dwindle down to nothing anyway.

Superconducting Ceramics: Using Microwave Energy

Ramesh Subramanian
Dept of Electrical Engineering, University of Utah

Microwaves are electromagnetic waves with frequencies in excess of 300 MHz. These waves travel at the speed of light and can be converted into heat energy. Of the various frequencies of interest, four are being selectively used for industrial, scientific, and medical uses. These frequencies are:

915 MHz + 25 MHz
2450 MHz + 50 MHz
5800 MHz + 75 MHz
22125 MHz + 125 MHz

The frequency of interest is the 2450 MHz which is currently used in commercial microwave ovens [1-2].

Basics of Microwave Heating

A microwave oven is used as an example to demonstrate the basic heating principle. The oven consists (among other things) of a microwave generator called **Magnetron.** These generators produce coherent wavelengths in a narrow spectral band which is converted into heat. These microwave generators are electron tubes with an anode and cathode.

The anode has an electron emitting material deposited on it as well. When significant voltage is applied between the anode and cathode, an electric field is generated. This field is combined with a magnetic field (from an electromagnet or permanent magnet) the interaction of which gives rise to a microwave field. At the same time, the electrons which have also been emitted from the anode vibrate with the microwave field and transfer their energy to this field, thereby creating a source of microwave power. This power is then radiated through an antenna. The desired microwave frequency is obtained by adjusting the length of the resonant cavity within the magnetron.

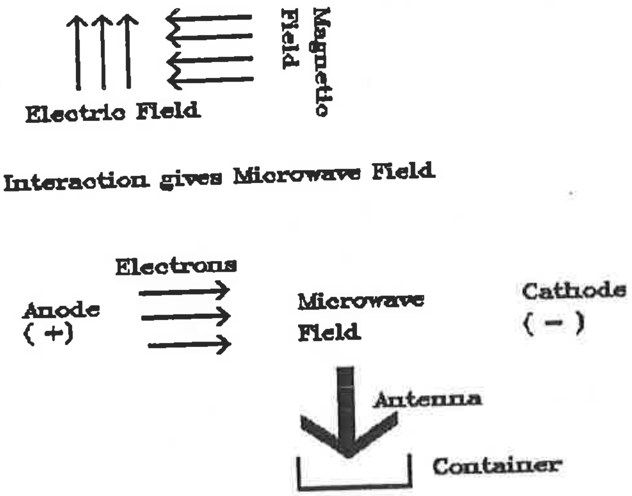

Fig1.

Figure 1. presents a pictorial view of this process. Conventional heating techniques usually require a very long time, typically 12 to 24 hours for synthesis of some superconducting ceramics. This is because there is no localized heating unlike in the case of microwave heating. The potential for rapid heating of some materials using microwaves can lead to the synthesis of some superconducting ceramics within a fraction of the time that conventional heating techniques require. The effect of microwave heating on various materials differ mainly because of the varying amounts of absorption of microwave energy by the different materials.

Table 1. provides data which illustrates the effect of microwave heating on the temperature of some elements and compounds. This data is mostly obtained from Reference 3. The temperatures indicated in the table are the maximum temperatures obtained within the time interval given.

Microwave synthesis of superconducting ceramics are of interest because this provides a convenient and rapid mode of synthesis. An example of such a synthesis is discussed next and is based on the work of Baghurst et al [4]. They synthesized $YBa_2Cu_3O_{(7-x)}$ using CuO, Y_2O_3, and $Ba(NO_3)_2$

in the appropriate ratios. They heated this mixture in a modified microwave oven which enabled the liberated NO_2 gas to be expelled safely. They treated this mixture with microwave radiation for 5 minutes at a power level of 500 Watts till all the NO_2 was liberated. The mixture was then reground and exposed to microwave radiation first for 15 minutes and then reground and exposed for additional 25 minutes at various power levels between 130 to 500 Watts. A final exposure for 25 minutes to microwaves resulted in an essentially pure sample. They also observed that the final superconducting orthorhombic form was achieved (from the tetragonal form) by slow cooling.

TABLE 1

Effect of Microwave Heating on the temperature of reagent grade elements, compounds & minerals[3]

Chemical	Temp oC	Time (min)
Aluminum	577	6.00
Carbon	1283	1.00
Copper	228	7.00
Cupric Oxide	1012	6.25
CuS	440	4.75
Cu2S-Chalcocite	746	7.00
Iron	768	7.00
Fe2O3	134	7.00
Fe3O4	1258	2.75
CaCO3-Marble	74	4.25
Plastics	<150	5.00
Pyrex	<150	5.00
Magnesium	120	7.00
SiO2-Quartz	79	7.00
YttriumChloride	40	1.75
Zircon-ZrSiO4	52	7.00

Note that Table 1. indicates that Marble, Quartz and Zircon would make good possible container materials depending on other compatibility, such as little or no reaction with the contents, as well as their ability to withstand the higher temperatures reached by the contents without decomposition and or defomation. Also note why most of the common metals are tabooed from being used as the container materials for cooking in the household microwave ovens.

Sometimes it is interesting to note the chemical contents kept in alumina boats glow (white hot, $>1000^{o}$C) with a little addition of lye (NaOH) and some transition metal compounds and break the pyrex plate holding the alumina boat without a microwave heat insulator in between.[5]

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WHY NOT OTHER COMPOUNDS? (Part III)

Neale R. Neelameggham

Brief mention of Thallium - Alkaline Earth Metals (Ca, Sr, or Ba) - Copper oxides, Bismuth - Alkaline Earth Metals - Copper Oxides and their relative higher T_c's between 90^{o} and 125^{o} K have been made in the last two issues of Let's Levitate.

Further work in the YBaCuO systems continue. Substitution of copper with nickel or iron or chromium in the partial levels (1 to 30% substitution of copper) have been noted to decrease the T_c considerably. The chromium substitution to a 10% (atomic) reduces the Tc from 91^{o} to 80^{o} K.

Partial replacement of both Y and Ba by Zirconium is found to be less preferred than partial substitution of copper with the tetravalent (initial) zirconium while keeping the proportions of Y and Ba similar in the $Y_1Ba_2Cu_3$ Oxides. (B. Jayaram, et al., *Mat. Res. Bull.*, V.23, pp 701-705). Similar results of little or no drop in T_c was noted about part substitution of copper with titanium by Okura, Ohmatsu, et al of Sumitomo Electric Industries, Osaka (*Jap. J. of App. Phys. Letters*, April 88, pp 1655-667). They report that zero resistance (within experimental measurement accuracy) was observed up to 300°K in $Ba_2YCu_{2.4}Ti_{0.6}O_y$. Most of the confirmed T_c values were in the 85° to 97° K range.

By special control of sintering and annealing Wada, et al were able to get a 92° K T_c for $LaBa_2Cu_3O_{(7-y)}$ (*Applied Phys. Lett.* 52 (23), 6 June 1988). The trick is to sinter above 950° C in nitrogen atmosphere followed with annealing at 300° C in dry oxygen gas.

More and more researcher's have published results doubting the existence of trivalent copper in the YBaCuO superconductor. More light is shed to confirm parts of the theory (published by the author in *Let's Levitate*, February 1988) on the potential presence of peroxide type species in the compounds aiding in the high T_c superconductivity.

M. Kao, Johnson Controls, Inc., Milwaukee, Wisconsin showed that mixing barium peroxide, cuprous (univalent Cu) oxide and yttrium oxide and sintering in argon around 930° C results in 123 compound with a T_c between 84° and 90° K.

Hepp and Gaier of NASA Lewis Research Center published similar results using barium peroxide, cupric (divalent Cu) oxide and yttrium oxide in *Material Research Bulletin* V.23 pp 693-700, showing better homogeneity in the resultant compound.

Let's Levitate pointed out in August 1987, that cupric oxide decomposes to cuprous oxide above 900° C sintering and that oxygen annealing continues to enrich the components of YBaCuO compounds. Additional insight into the peroxide theory will be published in the forthcoming issues.

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LETS LEVITATE

The Superconductor Hobby Club
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August 1988

Densification of Superconductors

Dr. Elangovan (Ceramatec Inc., Utah)

Densification is the major goal for most applications using ceramic materials; it improves the strength of the ceramic part. The starting material, in the powder form, is pressed with a suitable binder to form the desired shape. Depending upon the powder compaction, they are typically 25 to 60% porous. The compact is then processed to achieve near theoretical density. Typical densification process involves firing the porous green ceramic body at a temperature where material transport occurs through diffusion. This process is known as pressureless sintering. However, hot pressing and hot isostatic pressing (HIPPING) to enhance density are very common. The driving force for densification is reduction in surface energy of the particles. Various material transport mechanisms that occur during sintering are discussed in reference [1].

Pressureless sintering is usually preferred, since it allows several parts to be fired simultaneously, as well as being economical. Sintering causes almost a surface fusion between the particles (at the grain boundaries) and gives the finished part reasonable strength. Sometimes, a sintering aid is added to the material which forms a liquid phase and penetrates the grain boundaries; thus helping rearrangement of particles for better packing, improves material diffusion and results in high density.

One of the major problems in processing high T_c superconductor material is achieving high density. Typical sintered density is far below theoretical density. The theoretical density has been calculated to be 6.3 gm/cc for $YBa_2Cu_3O_7$ (1-2-3) compound [2].

Most ceramicists and physicists have used solid state reaction between Y_2O_3, CuO and $BaCO_3$ to prepare the superconducting compound and have experienced difficulties due to the presence of a second phase leading to incongruent melting, chemical demixing and segregation of phases.

The formation of a liquid phase due to incomplete mixing of powders is a tempting invitation to try liquid phase sintering for achieving dense superconductors. A recent attempt by Hwan, et al. [3] resulted in increased density. However, penetration of non-superconducting liquid phase into grain boundaries, isolated the superconducting grains and the resistance dropped to a finite value upon cooling. A hot press method to prepare dense $La_{1.85}Sr_{0.85}CuO_4$ was tried by Yoshizaki, et al. [4]. The properties of the superconductor formed were inferior to the one prepared by pressureless sintering method using the same powders. For example, the transition width was 5° K compared to 3.2°K for the pressureless sintered material.

Another method tried was the melt quench technique [5]. The density of the material, 1-2-3 compound was fairly high (5.4 gm/cc). However, the X-Ray diffraction indicated the presence of a mixture of phases. Annealing the quenched sample increased the amount of superconducting phase, while density dropped to about 5.2 gm/cc. A reaction between the usual oxide, carbonate mixture with a low melting $Ba_2Cu_3O_5$ pellet [6] showed a near theoretical density, but further analysis showed a mixture of phases. A sinter forging method is claimed to yield greater than 95% dense superconducting 1-2-3 compound. However, the sample had various phases with the desired phase being the inner-most.

In spite of the various attempts made, preparation of dense superconducting compound is still elusive; the major problem arises from the incongruent melting point of the starting mixture producing different compounds, not all of which is superconductive.

References:

1. Kingery, et al., Introduction to Ceramics.
2. S. Jin, et al., Appl. Phys. Letters, vol 51 (1987) 943.
3. N.M. Hwang, et al., J. Am. Ceram. Soc., vol 71 (1988) C210.
4. R. Yoshizaki, et al., Jap. J. Appl. Phys., vol 26 (1987) L311.
5. T. Komatsu, et al., Jap. J. Appl. Phys., vol 26 (1987) L1272.
6. A.M. Herman, and Z.Z. Sheng, Appl. Phys. Letters, vol 51 (1987) 1854.

SC FORUM

● Argonne National Laboratory has successfully completed their first year of a program called Argonne Affiliates Program in Superconductivity (ARCH) to provide industry first hand access to Argonne Research in high temperature Superconductivity.

Since their program's inception in late 1987, a total of ten affiliates have been registered. The affiliates include both Fortune 500 corporations and small entrepreneurial firms.

The items to which the affiliates are entitled include:

- Journal and report preprints, flash bulletins on superconductivity advances and publication lists.
- An Argonne based office for inquiries,
- Summaries of Research results.
- Market surveys of potential applications.
- Consulting services from Argonne Scientists.

Interested parties can contact Dr. Richard C. Jenner, Argonne National Laboratory, 9700 South Cass Avenue, Illinois 60439, (312) 972-7928.

● Technology Futures Inc., announces that an international conference entitled, "The Practical Commercialization of Superconductivity: Business Applications and Opportunities" will be held September 29-30 in Austin, Texas.

Dr. Vanston, Technology Future's President, states that this conference is designed to provide its participants with practical insights on the latest developments in the short, -mid- and long- term commercial applications of Superconductivity.

The conference fee of $150 includes meals during conference. Those wishing to attend should contact Nancy Powers at (512) 343-6468 for further details.

Technology Futures feels that larger scale applications in the fields of magnetic separation, superconducting motors and localized power and signal transmission would follow initial applications in levitation toys, motor bearings and instrumentation.

- Superconductor Applications Association in conjunction with Technova Inc., Tokyo, is organizing *"SC Japan 88"* to feature Japanese Superconductor Developments.

"SC Japan . 88: International Superconductor Applications Symposium and Tour" will be held in Japan on October 2-6, 1988. This program attendees will visit major Japanese Research facilities, hear detailed reports on the latest developments and would be able to meet one on one with the Japanese companies of their choice.

For further details contact SCAA, 24781 Camino Villa Ave., El Toro, Ca., 92630, (714) 586-8727.

SCAA, a non-profit, member supported trade association, is also sponsoring *"SC Global 89"* convention, including *"SC Global 89 Expo"* a trade show for Superconductor Applications during January 11-13, 1989. This program will be held at San Francisco Hyatt Regency Hotel.

- Indian Institute of Technology, Madras, India, (alma-mater for some members of Let's Levitate's Editorial Board), is one of the major centers of high T_c superconductivity studies in India. They have a journal titled *"High Temperature Superconductors"* which publishes related work from the several centers of high T_c research and development in India and other countries.

Those interested contact, Editors, G.V Subba Rao or R. Srinivan, High Temperature Superconductors, Indian Institute of Technology, Madras, 60036, India.

- *"High T_c Update"* published for the Office of Basic Energy Sciences, U.S.D.O.E., from Ames Laboratory, Iowa State University is an excellent source of Preprints listing, with the title of article, names of authors and addresses. The listing contains information on articles submitted to various science publications by researchers across the globe.

Please address all contributions and enquiries to Ellen O. Feinberg, 12 Physics, Ames Laboratory, Iowa State University, Ames, Iowa 50011 - 3020, (515) 294-3877.

SCUIPS

R.S. Liu, P.T. Wu, J.M. Liang and L.J. Chen of Materials Research Laboratories, Taiwan, have formulated a thallium compound with the composition $TlCa_4Ba_3Cu_6O_x$. The T_c onset for this compound is claimed to be 195°K, with a zero resistance shown at 162°K.

T.W. Huang and L.H.S. Wong, Taiwan, report that the most appropriate conditions for the formation of the superconducting Y123 phase is isothermal heating at 907°C for 16 plus hours. The insulating Y_2BaCuO_5 (Y211) phase exists between 987 and 1190°C. The semiconducting phase $YBa_3Cu_2O_{7-y}$ (Y 132) phase coexisting with the 123 phase disappears only after prolonged soaking at 907°C. The Y123 phase exists only between 820 and 996°C. Their studies utilized DTA, TGA and XRD techniques.

Most other recent advances in the field of high T_c compounds mainly evolve around defining and redefining the structure of the compounds, as well as various synthesizing techniques for both bulk and thin film high T_c superconductors.

Neelameggham and J.F. Reilly of SHC have submitted a different structural model **"PEROXVITE"** for publication. This model tries to explain the role of peroxide/ superoxide compounds in the formulation and properties of superconductivity in the high T_c compounds. Suggestions for designing other compounds with higher T_c are noted.

T. Siegrist, et al. of A.T.& T. (Nature, v 334 (21 July, 1988)) describe the growth of single crystals of a phase with composition $Ca_{0.86}Sr_{0.14}CuO_2$ and indicate that the structure of this compound can be regarded as the parent structure of $A_2B_2Ca_{(n-1)}Cu_nO_{(4-2n)}$ (A=Bi, Tl; B=Sr, Ba) superconductors.

S.S.P. Parkin, et al., of IBM (Phys. Rev. Lett., v 61 (8 August, 1988) 750) report the discovery of additional new phases in the Tl-Ca-Ba-Cu-O system. The compound $TlCa_2Ba_2Cu_3O_9$ exhibiting a T_c of 110°K supposedly has a monolayer of Tl-O sheet separating the copper perovskite like units, while another composition $Tl_2Ca_2Ba_2Cu_3O_{10}$ with a T_c of 125°K has a bilayer of Tl-O sheet separating the perovskite-like units.

A neutron powder diffraction study of $Ba_2YCu_3O_7$ is reported by D.E. Cox, et al., of Brookhaven National Laboratory (J. Phys. Chem. Solids, v 49, No. 1 1988, 47-52). They note that although the X-Ray studies are in general agreement concerning the positions of metal atoms in $Ba_2YCu_3O_7$, there is no general consensus about the distributions of oxygen atoms and vacancies, which is regarded as an important factor with respect to superconducting properties. The SHC agrees with Dr. Cox's evaluation; some additional clues may be available in the paper submitted for publication by Neelameggham and Reilly of SHC.

Yamaguchi, et al., of Osaka University report on *"Possible Organic Analogues to Copper Oxides: Applications of a J Model"*. (Jap. J. of Appl. Phys., v 27, No. 5 (May 1988) L766-769.).

W.K. Ham, G. Holland and A.M. Stacy of University of California, Berkeley, (J. Am. Chem. Soc., V 110 (July, 1988) 5214), discuss a low temperature synthesis of superconducting $La_{(2-x)}M_xCuO_4$ by direct precipitation from NaOH/KOH melts. The T_c of these compounds, however, are less than 35°K.

Transistors

Arun Ramadorai

The transistor was invented at the Bell Telephone Laboratory in 1948 by Dr. William Shockley, Dr. Walter H. Brattain and Dr. John Bardeen. These men were given the Nobel Prize in Physics in 1956.

The first transistor was big and bulky and hard to use. Now it is no bigger than a fingernail. There are three basic transistors: a PNP, an NPN and a Power transistor. NPN and PNP stand for N-Germanium and P-Germanium. Germanium, an element, is a semi-conductor that is specially treated for use in a transistor. The germanium plates are about the size of a period at the end of a sentence.

Compared to a vacuum tube, the transistor is tiny. It also needs no warm-up time, and works on lower voltage. Transistors have special signs in schematics. Each plate is a sandwich of P and N material. The material is organized in two patterns: PNP or NPN.

Transistors amplify power. They have different amplifications. The amplifications are rated by numbers written on the transistor face. When an alternating current (AC) is put into a transistor, it can be amplified as much as 100 times.

A transistor has three legs. These three legs are the base, emitter and the collector. A transistor works when electrons in the emitter are waiting to go through the collector. They go through the collector when voltage is applied at the base. In other words, there are locations for electrons to hop through and make electricity flow.

There are other transistors like a photo-sensitive transistor that connects the circuit between the emitter and the base when hit by light.

Transistors with four legs are called IC's. The extra leg can be two bases, two emitters or two collectors. IC is the abbreviated term for an Integrated Circuit (in a Chip). IC's are micro-chips that can be used instead of bulkier large component circuits. Transistors can be put into IC's which makes them smaller.

The transistor has many uses in TV's, telephones and other electronic devices. The difference between an electronic and an electric device is that an electronic device has transistors while the electric device does not.

On Submitting Articles

Articles on superconductivity and related interests are welcome. Please submit articles either in double space typed format or as an ASCII text file in 5.25inch floppy disk for IBM PC compatibles. Or the articles can be uploaded to Mount Olympus BBS (Tel: 801-942-0620); and call 801-596-3592.

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A Canadian Science Fair Project

Cameron S. Ogilvie

In the fall of 1987, at the beginning of my grade eight school year, I began to notice articles in the newspaper about Superconductivity. I decided that this would be a great topic for the upcoming science fair at my school.

The first step was research, including clipping out articles from newspapers and magazines, going to the library to gather technical papers, and writing letters to the people mentioned in the articles. At this time I did not know if this project would be possible, but all the articles said that making a 1-2-3 Yttrium-barium-copper superconductor was rather easy.

After several weeks of research I was nowhere near completing my science fair project. The most important thing was missing, the superconductors!

I started looking through local sources of chemicals and equipment. After a while I was referred to Doctor Rutter in the Department of Metallurgy at the University of Toronto. I phoned him and asked where I could find all the necessary equipment. He said that all the necessary equipment was located in his lab and invited me to his lab to discuss my project in further detail.

Professor Rutter and his assistant, Simin Bagheri, showed me where all the equipment was and how to use it safely so that I could start making my superconductors.

For the next two weeks I went there every day after school to mix, grind, bake, press, and test my samples. Out of all my attempts I achieved a 72% success rate!

At that time I received two letters. One from Neale Neelameggham, who gave me a letter containing helpful hints and three samples. One was mixed ready for the first bake, another already had the first bake but needed pressing and final baking, and the last sample was a pellet which was all processed but still needed the final bake.

The pellet was smashed and half of it was missing. The letter had three holes punched through it and the envelope had a hole through it as well. Oh how we all love the post office!

The second letter I received was from Mr. Srinivasan. This letter contained great information about building kilns, dies, presses, and the other equipment if I was not able to get access to all these things.

I reground Neale's broken pellet and pressed it into a wafer at 24000 P.S.I. When grinding the powder to a fine black dust I mixed it with rubbing alcohol. When the sample is pressed, the alcohol lubricates the powder so it is packed into a more dense form.

When in Doctor Rutter's labs I noticed that they use extremely long baking times for their samples. The samples are in the kiln for the first bake for 24 hours at 950 degrees Celsius.

After the first bake the samples were immediately removed from the kiln and allowed to cool in the open air for 10 minutes. This seemed strange because most of the articles I read said that the samples must be cooled slowly for the first and second bake.

After the samples were cool enough to work with, they were pressed into a wafer at 24000 P.S.I. The wafers are one inch long and one quarter of a inch wide. The height depended on how much material was loaded into the die.

The press was just a simple hydraulic jack with an oil pressure gauge and a heavy structured housing for the die. The die went in between two very thick steel plates. The housing consisted of very large bolts, a steel plate for the bottom, the hydraulic jack, and the steel plates for the die chamber.

After the samples were pressed they were put into a quartz tube kiln for 72 hours! During the first 24 hours of the bake the temperature was 950 degrees Celsius, for the next 32 hours the temperature was 700 degrees Celsius, and for the last 16 hours the temperature was 400 degrees Celsius.

During the duration of the final bake, oxygen was pumped through the tube at a rate of about one litre per minute. At the end of the tube was a rubber stopper with a latex tube leading from it, the tube led to a bubbler which cooled the hot gas and filtered the bad elements out of the air that were picked up from the superconductors.

The baking took an extremely long time and the one inch kiln limited the maximum size for my samples.

The school fair was rather easy for the exhibitors. All you had to do was set up your project and walk away. The judges came along later to read your project's documentation and experiment with the apparatus. The next morning after the judging was finished the students were notified of the results. My project had been placed first in the Physical Science Division!

Later that day my science teacher suggested that I enter my project in the Metro Toronto Science Fair. After filling out an entry form and writing the required essay, my project was accepted.

This time the competitors were required to be at their projects for the judging. We were required to explain our projects and give a demonstration if required. After the judging was over we were required to stay at our projects and repeatedly explain to the public for two whole days what our project was about before the results were given. At the awards ceremony I found that my project had again been placed first.

From the Metro Toronto Science Fair, six lucky students were chosen to the Canada-Wide Science Fair. This year the Canada-Wide Science Fair was held in Winnipeg, Manitoba.

During our stay in Winnipeg we were kept very busy, setting up projects, going on tours, and seeing the sights (it's flat!). After the judging was over we had to wait three whole days before we found out what happened. During this time the science fair was open to the public, so we had to sit at our projects all day for three days while explaining to the public what we did.

On Friday, two days before we left Winnipeg there was an awards ceremony presentation. My project received an honorable mention at the Canada-Wide Science Fair!

Next year I hope to be able to experiment further into superconductivity using some of the latest chemicals and will try to demonstrate some of the applications of superconductivity.

My thanks to the members of the Superconductor Hobby Club for their assistance.

Cameron S. Ogilvie (23 Croydon Road, Toronto, Ontario, Canada. M6C1S6 (416) 789-3530) is another young member of SHC; the editorial board applauds his efforts and achievements).

Letters to the Editor

Dear Editor:

Thank you for your letter of Aug. 24th and the copy of "Lets Levitate" in which you refer to our paper on the structure of $Ba_2YCu_3O_7$.

I would like to emphasize that our comment made in the Introduction to this paper about there being no consensus about the distribution of oxygen atoms and vacancies referred only to the x-ray measurements described early in 1987; as pointed out later in the paper, the many neutron studies carried out since then are in excellent agreement concerning the positions of the metal and oxygen atoms.

It is certainly not my evaluation that there is any lack of consensus at the present time as stated in your newsletter, in fact quite the reverse. I would appreciate it if you would correct this assessment in a subsequent edition of the newsletter.

Although there have been many speculations about the possibility of peroxide and superoxide ions in $YBa_2Cu_3O_7$-type materials I am not aware of any definitive evidence for this from x-ray or neutron diffraction studies, including our own.

The O-O distances are not usually considered to be of primary significance in these studies and are not normally quoted; however, you can calculate them easily from the atomic positions. I am unable to identify the specific comment on "lack of oxygen-oxygen distance studies" to which you refer in your letter.

David E. Cox
(Brookhaven National Laboratory, Associated Universities Inc., Upton, Long Island, New York 11973. Tel:516-282-3818)
October,1988.

(The SHC appreciates Dr. Cox's response about our interpretation of his article written in 1987.)

Dear Editor:

The following people are interested in "Let's Levitate". These people would like to write some articles for the newsletter.

Arun's science fair Project is to demonstrate how a computer can send signals to the printer using light lasers instead of electrical cables. Arun is to build and design his own circuit board with Mr. Williams' guidance. Mr. Williams tutors Arun in Electronics. Three of Mr. Williams students levitated a "wafer" last year. We hope we can see it if he does it this year.

R.D. Boyt is currently working on formulas to describe accurate on two-dimensional plane three dimensional configurations. He was the original stimulus in our family for low cost solar energy producers: these are low-technology solutions for heating and cooling devices that ordinary people can make for themselves.

A.D. Boyt and his team built and ran the first solar-powered car to cross the continental U.S. He raced the second car last year in Australia and has received both the State and National award for excellence from the Energy Commission. David Boyt is another generally creative person; He is the (Macintosh) Computer Consultant for Pitsco, a Mail Order school supplies outfit.

Arun has told his barber about superconductors and once he starts talking about the future when trains will be run on them it's more than he can understand. "Hey, Joe, come over here and listen to this kid", the barber calls out. They think he's been reading too many comic books and it's very funny to them but Arun is totally unaware of this and happily goes on into a future vision only he can see.

Elizabeth Ramdorai, Elko, Nev.
September 1988.
(Arun Ramdorai is one of the earliest and youngest members of the SHC. We welcome all new members and their comments and articles)

SCUIPS

In September Dr. W.A. Goddard III, Guanhua Chen, Yuejin Guo and Jean Marc Langlois of Caltech revealed their quantum mechanical model of high T_c superconducting oxides, using a magnon-pairing theory. Their theory also disputes the presence of copper in the trivalent state. As noted in High T_c Update (Oct 15,1988), *'oxidation beyond the cupric state leads not to trivalent copper but rather to oxidized oxygen atoms, with an oxygen p hole bridging cupric (+2 valence) sites'*, etc. According to Goddard, et al., the maximum temperature of superconductivity in the copper oxide compounds is in the 205 to 225°K range.

M. Leskela, C.H. Mueller, J.K. Truman and P.H. Halloway of the University of Florida, Gainsville, compare the preparation of YBaCuO superconductors using $BaCO_3$ with those made using BaO_2, in their article published in Material Research Bulletin (vol 23, pp1469-1477, 1988). They note that the use of Barium peroxide helping the formation of the high T_c superconducting phase, at a slightly lower temperature in air than using Barium Carbonate.

Their interpretation of the results from processing under helium atmosphere differs from the results shown by Hepp and Gaier for inert (nitrogen) atmosphere processing. The U of F team managed to create a miracle such as *'inert gas reduction of metal oxides to metals'*; probably even help throw light on the formation of new compounds such as helium oxides, etc.

One wonders, if they ever checked the hydrogen impurity in helium, which is capable of reducing copper oxides to copper metal. It will be interesting to check what happens when purified argon (with hydrogen, carbon dioxide, and oxygen getters)is used as an inert gas medium in the processing of Y_2O_3 -BaO_2 -CuO.

W.P. Kirk, P.S. Kobiela, R.N. Tsumura and R.K. Pandey of Texas A & M University, will be reporting on the *'Thermal Conductivity of hot-pressed 123 YBCO superconducting oxides: Anisotropic Behavior at high and very low temperatures'*, in the journal Ferroelectric.

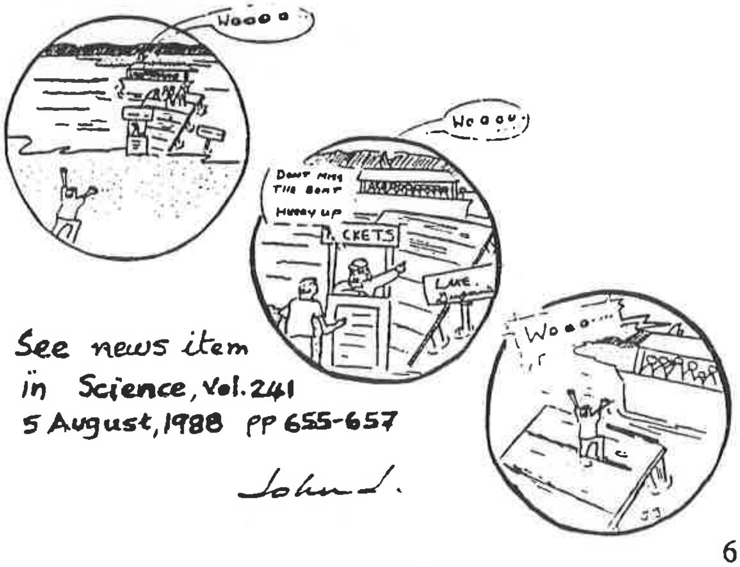
Additional TGA work on high T_c compounds can be seen in the Material Research Bulletin, (vol 23, pp 1211-1217, 1988) in the article by E. Schoenherr of Max-Planck-Institute for Physical Sciences, Stuttgart, Fed. Rep. Germany. Their studies indicate the different temperature required for maximum oxygen incorporation during annealing is at 560°C in oxygen atmosphere, but is only 450°C while processing in air.

'Levitation effects involving high T_c thallium based superconductors', is discussed by W.G. Harter, A.M. Hermann and Z.Z. Sheng, of the University of Arkansas, in applied Physics Letters (vol 53, 19 September 1988, pp 1119-1121).

Preparation of the superconducting sample, which exhibits very stable levitation equilibria, has been described the same authors, in Nature (vol 332, 138 (1988)).

ACS symposium held during September 1988, included several presentations on high T_c superconductors and on conducting polymers. Emanuel I. Cooper, IBM, (Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598), discussed the use of manganese-EDTA chelate in selectively analyzing for peroxides in the high T_c superconductors.

The forthcoming Annual Meeting of the Journal of Electrochemical Society, will include a session on high T_c superconductors with 37 papers. *'Preparation of alloys of Y-Ba-Cu by electrodeposition as precursor for high T_c superconductors'* by W.C. Grande and J.B. Talbot, University of California, Sandiego, and *'Superconductor Films via an Electrodeposition Process'* by M. Maxfield, et al., Allied Signal are two of the noteworthy papers, discussing electrolytic deposition of the high T_c oxides.



See news item
in Science, Vol. 241
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John J.

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SC FORUM

- Superconductive Components, Columbus, OH has announced the availability of a series of demonstration kits designed to allow the user to investigate the unique properties of superconductors.

Their press release indicates the availability of the following kits:

Model SC 1000 - "Superconductor Test Kit", $195.. Kit to demonstrate transition from normal to zero resistance state.

Model SC 5000 - "Variable Temperature Characterization System" $535.. Kit allows unique testing means to characterize upto two superconductors simultaneously over a wide temperature range.

Model SC10000 "Superconductive Disc Fabrication & Test Kit" $650.. Allows the user to manufacture upto ten different superconductors.

Those interested contact J. R. Gaines, Vice President, Superconductive Components, 1145 Chesapeake Ave., Columbus, OH 43212. (614-486-0261).

- The Materials Research Socety expects over 4000 attendees at their 1988 Fall Meeting scheduled for November 28 - December 3 in Boston. The symposium on High Temperature Superconductors has been expanded to include over 180 papers. MRS Fall Meeting Pre-registration ($160, Students/$50) can be made by phone at 412-367-3003.

The MRS, is a non-profit sciencntific organization. Their symposium will include other topics such as Liquid Crystal Polymers, New Materials Approaches to Tribology, etc.

- Several different types of furnaces such as -- Tube Furnaces... Split Tube Furnaces ... Box Furnaces ... Controlled Atmosphere Furnaces -- made by Applied Test Systems, Inc. are available through Highland Technical Marketing. Contact J. Dean Jones, Highland Technical Marketing, American Fork, Utah (801-756-2634).

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1145 Chesapeake Ave., Columbus, Ohio 43212. Attn: Greg Barnum, (Tel:614-486-0261). SHC members can obtain the Commemorative color poster on American participation in superconductor research, free of charge, for the cost of postage and handling. This would be a useful addition to any Science Fair Exhibit.

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LETS LEVITATE

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1915 Zachary Drive, Salt Lake City Utah 84116
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S.C.Forum

Technology Research Corporation, Springfield, Virginia wishes to announce the publication Superconductivity Sourcebook. '**The Superconductivity Sourcebook**, written by V. Daniel Hunt, Technology Research Corporation, provides a comprehensive and highly informative overview of superconductivity, description of significant applications, market potential analyses, current status of technology commercialization; more than superconductivity related definitions,....reference information including printed and video resources are provided'. This sourcebook meant for the industry for both the scientific and business personnel is written in understandable style, also includes several related illustrations. The Superconductivity Sourcebook is published by John Wiley & Sons, Inc., One Wiley Drive, Somerset, New Jersey 08873, (201) 469-4400, is available in December 1988 for $32.95. (Technology Research Corporation, Springfield Professional Park, 8238-A Traford Lane, Springfield, Virginia 22152. (703)451-8830.)

The Materials Research Society's press releases note the following highlights:

o The highest honor the Materials Research Society bestows for the outstanding interdisciplinary contributions to materials research, the Von Hippel Award, for 1988 was awarded to Professor Jacques Friedel, Head, Department of physics, University of Paris, Orsay on Nov 30.

Friedel has made pioneering contributions to the understanding of behavior of dislocations and strength of materials, electron theory of metals, and the properties of alloys. Among them are the Friedel sum rule for impurity screening, the Friedel charge oscillations around impurities, the concept of spin glass, etc.

o Fifteen graduate students belonging to several US universities and University of Catania, received the MRS Awards for chosen papers presented at the MRS, Fall 1988 Meeting. The students selected have an international background working in multi-disciplinary materials research. Brent Richert, Texas A&M University, received his award for his paper on the *'Preparation and Materials Properties of High Temperature Superconductors'*.
(Materials Research Society, 9800 McKnight Road, Suite 327, Pittsburgh, PA 15237, (412)-367-3003)

The Superconductor Applications Association reminds all of its forthcoming International Superconductor Applications Convention, in San Francisco during January 11-13, 1989. (Superconductor Applications Association, 24781 Camino Villa, Ave., El Toro, CA 92630, Tel(714)-586-8727.

Those interested in participating in a questionnaire/survey on high-temperature superconducting ceramics, both on the Large Scale and the Small Scale Applications of High Transition Temperature Superconducting Ceramics, can contact the Superconductor Hobby Club, 1915 Zachary Drive, Salt Lake City, Utah 84116, (801)596-3592. Your answers will be forwarded to the survey being assembled by the Gorham Advanced Materials Institute, following a summary compilation related to SHC.

The Council on Superconductivity for American Competitiveness (1050 Thomas Jefferson Street, N.W., 6th Floor, Washington, DC 20007,(202)965-4070), issued a 26 pages report on November 30. The report titled

"Progress Report and Critique of the President's Superconductivity Initiative". This report is for the evaluation of the present administration as well as for the newly elected President's group.

While commending the present administration's effort on initiating this program, the report states that *"the initiative.... met an entrenched bureaucratic buzz-saw head-on"*. Further adds *"So, while our federal officials can debate endlessly about the proper role of government, our major international competitors just assign a role, a technology target, and move forward. Our fear of industrial policy is precluding us from dealing with the development of a technology policy, which precludes any meaningful establishment of a superconductivity policy"*. And concludes, although the President's Initiative of July 1987 was a step forward, but *"CSAC sees superconductivity as a test and a challenge of the ability of United States to mobilize its resources in order to compete in a rich marketplace spanning the next millennium. And if we measure ourselves by present standards, modest standards represented by well-intended Congressional or Administrative proposals, we may well indeed falsely convince ourselves that we are doing enough to be competitive"*.

Those interested in commenting on and furthering the efforts of CSAC can send their views either to CSAC or through SHC which will forward it to CSAC, if needed.

Materials Technology Publications, (40 Southern Road, Watford, Herts, England WD1 2QA, Tel:(0923)37910.), announces the publication of their book **High Temperature Ceramic Superconductors** by Dr. John Briggs. -- at a cost of $720 (86983 yens).

SCUIPS

Shinya Hasuo of Fujitsu Laboratories Ltd, presented a paper during the Applied Superconductivity Conference held in August in San Francisco. Interpretation of his paper compares in simplistic common computerese the potential speed differences that can be achieved with a 4-bit microprocessor when built of different materials; Niobium-Aluminum Oxide technology would allow 770 MHz which compares with 30 MHz for an equivalent 4-bit silicon microprocessor or with 72 MHz for a 4-bit Gallium Arsenide chip. The 300 million dollar effort by IBM in the late seventies could not do this with their lead alloy superconducting Josephson-junction development. (Comments by Dr. M Kuchiner, in Cold Facts, November, 1988).

Report on Bulk Superconductivity up to 122 K in the Tl-Pb-Sr-Ca-Cu-O System by M.A. Subramanian, et al., of E. I. du Pont de Nemours and Company, Experimental Station, Wilmington, DE 19880, can be found in Science, October 14, 1988, page 249-252.

PHYSICA C is a new monthly Journal published by North-Holland Physics Publishing Company, Amsterdam, Holland. This new Journal has been brought out (since August 1988) to serve as an exclusive, rapid channel of the journal **PHYSICA A** for publications on superconductivity and related subjects.

WHY NOT OTHER COMPOUNDS:

Neale R. Neelameggham

Based on the efforts by the Superconductivity Hobby Club, during October through December **1987** the thallium compound that has the most potential for higher T_c than known at present is the Potassium-Thallium Oxide system with additional ingredients. The initial studies by Neelameggham, Joven Calara, Radhakrishnan, Gopalakrishnan and Srinivasan established the ease of making a conductive oxide with Cu-Tl as well as the K-Tl system. Whereas, the Cu-

Tl system showed a drop in resistance with cooling to liquid nitrogen, the K-Tl-O system starts with about equal or less room temperature resistance than the copper-thallium system, but demonstrates a temperature invariant resistance to the liquid nitrogen temperature, excluding the contact resistance.

Further, this SHC work is based on the basic synthetic chemistry approach of Peroxvite Theory reported by Neelameggham and Reilly of SHC. Further work in the potassium-thallium system would shed more light on higher temperature superconductivity; those interested in further details can contact SHC.

Requests for the SHC report on the "Peroxvite Theory of Superconductivity and Possible Organic Formulations", by Neelameggham and Reilly have been overwhelming, from all over the world. A synopsis of the peroxvite theory is presented below.

Basically, the peroxvite theory, perceives the superconducting oxides as compounds in which the alternate 3 dimensional layers have peroxide ions (O_2^{2-}) instead of every layer having only oxide (O^{2-}) ions. The peroxide ions facilitate the superconducting electron mobility. Most of the known high transition temperature superconducting oxides all have in their backbone stable peroxide forming cations, such as barium, potassium, strontium, calcium, etc., along with transition metal cations which form multi-valent oxides. The latter thus facilitate interactive bonding with the peroxide ions.

The SHC feels that since organic compounds' cationic groups behave much alike the alkali metal ions and are known to form reasonably stable (room temperature, however) peroxides, the formulations using these with low temperature processing would result in near room temperature organic or polymeric superconductors. Additional proof to this theory comes from the observation that among the polymeric compounds, those containing perthio (S_2^{2-}) compounds show the highest T_c of 4 to 6° K.

PRINCIPLES OF ELECTROMAGNETIC LEVITATION

(Excerpts from Modern College Physics, by H.E. White, D. Van Nostrand Company, Inc. 3rd Ed., 1954, pp 567-569.)

'The phenomenon known as levitation is another illustration of Lenz's law. A metal bowl B, as in Figure 1, is supported in stable-equilibrium in the mid-air just above an electromagnet M of special design. Top and side views of the iron core and coil windings are also shown. Excited by an alternating current, the raised iron knobs labeled N and S reverse their polarity periodically with the current.'

'As the electron current builds up in the direction indicated in diagram (b), the magnetic induction grows as in diagram (c). With the aluminum bowl in place as diagram (d), the growing field induces strong eddy currents in the aluminum conductor. These currents in turn give rise to opposing fields. Since the primary field being created by an alternating current increases and decreases rapidly, the bowl always experiences an upward force.'

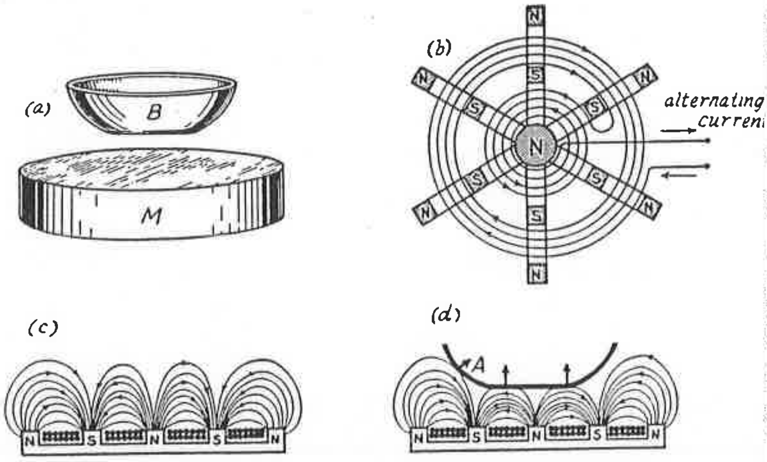

FIG. : I —Diagrams illustrating the application of Lenz's law to produce *levitation*. A met. bowl floats in mid-air.

'Should the bowl move to one side, as for example to the left in diagram (d), the changing field at A will induce stronger electron currents on that side of the bowl and give rise to an increased repulsion, pushing the bowl back toward the center as indicated. The strong induced currents give rise to so much heat that the bowl soon becomes hot.'

'Because the coil windings of a levitator have a relative large inductive reactance, a fairly large capacitance must be inserted in the a.c. circuit to raise the power factor close to unity and thereby keep the current in the levitator coils at a maximum and the current supplied by the source at a minimum.'

(This excerpt is published for the benefit of some of the SHC members interested in building Science Fair Levitation models. Variations, of this simple electromagnetic principles can be utilized to demonstrate simple devices).

LET'S LEVITATE
(For the Superconductor Hobbyists) Published Once in 2 Months.

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Hobby Supplies

YBC pellet for $20 Edmund Scientific,
Barrington, N.J., 609-573-6250.

1-2-3 Levitation Kit for $25. Arthur B. Ellis,
ICE Project 1-2-3, Dept of Chemistry,
U of Wisconsin, Madison, WI 53706. (probably discontinued since mid-88).

Knutsoft High T_c Demo Kit - $49.
Vallejo, California, 707-648-0779
David Rudd, President. (probably discontinued since mid-88).

YBC powder for $93/lb in 500 lb lots or more,
from Lambertville Ceramics, lambertville, NJ.
Tel. 609-397-2900 Richard Cass, President.

SC's with gold wires...$100 ea.
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Fluoramics Inc., Upper Saddle River, NJ.

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Hobby kits $100 to $200 range
303-634-0185.

Superconductive Components, Inc. 1145 Chesapeake Ave., Columbus, Ohio 43212.
Attn: Greg Barnum, (Tel:614-486-0261) SHC members can obtain the Commemorative color poster on American participation in superconductor research, free of charge, but for the cost of postage and handling. This would be a useful addition to any Science Fair Exhibit.